Conclusion

After three years of observation in two almond orchards of different maturities and soil types, significant differences in water consumption were found among the five treatments. In both orchards, total water consumption (used by plants and lost to evaporation) was less in the residual herbicide and chemically mowed treatments than in clover or resident vegetation treatments, on both a daily and a seasonal basis.

The differences amounted to a two-year average of 20.5% for the mature orchard (orchard B). Bromegrass, when managed to create a mulch (orchard B in 1985), resulted in greater early-season water use but reduced water use at mid-season; total seasonal water use was similar to that of residual herbicide and chemical mowing.

In orchard A, resident vegetation used 35% more water than did the residual herbicide treatment in the establishment year and 23.9% more in 1986. Bromegrass was intermediate in water use, varying each year mainly because of stand quality and mowing frequency.

Although the orchards represented different soil types and maturities, they both showed similar trends in water use by treatment. The treatment differential was magnified in the younger orchard, suggesting that the effect of orchard floor management systems on water use may be greatest in young orchards. The differential declined with orchard maturity, probably because of increased shading, competitive water use, and longer times between irrigations.

In evaluating effects of orchard floor management on soil characteristics, we detected a significant increase in surface soil compaction in the residual herbicide treatments in both orchards. No differences were found in soil-water holding capacity or water intake rate. Since changes in these soil physical characteristics are viewed as cumulative and the rate of change depends on orchard operations, further increases in soil strength in the residual herbicides may occur.

Selection of an orchard floor system should be based on the soil and management limitations of the orchard. If water supplies are limited, a system using residual herbicides, chemical mowing, or bromegrass would be appropriate. If water infiltration rates are poor, a different solution would be required. Either chemical mowing or bromegrass offers a combination of benefits in reducing soil compaction as well as minimizing seasonal water use.

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Almond orchard floor management costs

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In selecting an orchard floor management system it is necessary to evaluate the costs of developing and maintaining the systems under consideration. We estimated sample costs for the five systems studied as treatments of the centers between the tree rows—Blando bromegrass, Salina strawberry clover, resident vegetation, residual herbicide, and chemical mow, as described in the introductory article. These costs were also compared with costs of disking the centers between the tree rows and disking and mowing the centers, two traditional vegetation management practices in California not included in the field trials.

Annual costs of managing the orchard floor for each alternative were estimated based on the results of the trials. The actual costs of the trials could not be used because of the small size of each plot relative to a commercial orchard. In this report, we discuss the differences in orchard floor cultural practices, irrigation, and related costs. Cultural costs such as pruning, pollination, and brush removal are not included, because they remain the same regardless of floor management regime and are not really part of the floor management system.

Establishment and maintenance

Costs of managing the two planted cover crops, Salina strawberry clover, and Blando bromegrass, include seedbed preparation, seed planting, and extra fertilizer. The bromegrass was fertilized with nitrogen every year; the clover, a perennial, was fertilized with phosphorus plus some nitrogen only in the year it was planted. Costs in the establishment year were $74 per acre for bromegrass and $59 for clover (table 1).

In all of the systems, weed control along the tree rows with a pre-emergence herbicide application in December or January and a contact spray in May or June cost about $29 per acre per year (table 2). The strategies all differed in the way vegetation was controlled between the tree rows or along the middles. The nontillage systems all relied on mowing.

The planted covers were mowed seven times at a cost of about $31 per acre per year: twice before frost, once after seedheads formed, and four times during the season. Annual bromegrass fertilization cost $11.

The costs of establishing the planted covers (table 1) were allocated on an annual basis over the life of the orchard and are included in the annual cost estimates (table 2). Including the amortized establishment costs ($5 per year for clover and $7 for bromegrass) makes direct comparisons possible between the planted covers and the other regimes.

The resident vegetation was mowed eight times, once more than the planted cover crops, for a total cost of $35 per acre per year. This compares with about $39 for chemical mowing of the resident vegetation in the middles. Four applications of glyphosate were included in the chemical-mow cost estimates—two in winter, one in summer, and one to clean up the plants before harvest.

A combination of mowing and cultivating the resident vegetation cuts the number of mowings from eight to four and adds three cultivations. An alternative is to cultivate five times instead of mowing. Under either management regime, the orchard floor also must be rolled in preparation for harvest and sprayed with herbicide. Preparation for harvest adds two more operations, making nine for the mowing and cultivating option totaling $48, and seven for the cultivated orchard totaling $42.

Complete residual chemical control replaces the mowing and/or cultivating treatments with spraying herbicide in the middles at the same rate and timing as in the tree rows. An additional herbicide application is also required for preharvest cleanup at a total cost of controlling weeds in the middles of about $60 per acre. If weeds such as nutsedge, field bindweed, or prostrate spurge are present, a follow-up post-emergence herbicide treatment may be required in the summer.

Water use

Water use over the entire season varied substantially in the different vegetation management systems. In the experiments, resident vegetation used the greatest amount of water, 47 acre-inches per acre per season for a mature orchard, followed by the strawberry clover cover, 46.5 acre-inches per acre. Blando bromegrass used much less water, for a total of 38.2 acre-inches per acre. We assumed for the purposes of the cost analysis that an orchard managed by cultivating the middles would use the same rate of water as the complete residual herbicide plots and that the orchard managed by mowing and cultivating the middles would use the same as the resident cover plot.

Obviously, the cost savings associated with a reduction in water use would depend on the cost of water per acre-foot. We used a price of $28 per acre-foot in our estimates plus $3 an acre for irrigation labor. The cost of the irrigation system itself was not included. Given these prices, the cost of irrigating the bromegrass is lowest at $92 per acre and the resident cover and mow/cultivate regimes are highest at $113 per acre.

Insect control

Orchard A had a large number of southern fire ant and pavement ant colonies. Significant damage occurred to nutmeats in the resident vegetation and Blando bromegrass in 1985, 1986, and 1987, as reported by Barnett et al.

Ant populations and damage did not occur at the same levels in the same orchard floor management systems in both orchards. Based on the information from orchard A, however, the level of ant activity in the three vegetation systems would make insecticide treatment necessary. This orchard was treated in 1987 at a cost of $24 per acre. Although ant populations were relatively high in the residual herbicide system, the damage to nutmeats was not significant during any year.

In both orchards, the amounts of damage from navel orangeworms were not significantly different among systems (data not presented). No costs for navel orangeworm control are included.

Conclusion

Our cost estimates show that introducing a cover crop was more expensive than the other systems in the first year because of costs of seedbed preparation, seed, planting, and fertilizer. When costs of establishing the planted cover crops are amortized over 15 years, however, the total annual cost is equivalent to or less than the cost of mowing the resident vegetation. Although annual fertilization is needed for the bromegrass cover crop, one mowing can be eliminated in comparison with unplanted resident vegetation. Bromegrass also used substantially less water than the clover or resident vegetation regimes. The net result of all the differences among the vegetation covers comes to a total cost per acre per year of $170 for bromegrass and $177 for clover and resident vegetation.

Chemical mowing has a lower annual cost than any of the mechanically mowed regimes, at $162 per acre. Chemical mowing has the added advantage of requiring only four trips across the orchard compared with seven or eight for mechanical mowing. Also, the orchard floor does not have to be prepared before harvest in any of the nontillage systems. This reduces equipment use and operator time, freeing both for other farm operations as well as reducing maintenance costs. If the costs of materials used for chemical mowing decreased, this alternative would become even more attractive.

Combined mowing and cultivating at $190 per acre is more expensive than any of the other mowing regimes because of the high water use and the need to prepare the orchard floor before harvest. Cultivation at $165 per acre is less expensive than any of the mechanical-mowing regimes, despite the need to roll and apply herbicide before harvest, because the water use is lower. Cultivation requires the same number of operations with equipment as do planted cover crops. However, because of the two operations needed right before harvest when there are other demands on the grower, cultivated centers are not popular in many orchards.

The residual herbicide regime, at $183 per acre, is expensive because of the cost of herbicides applied. It was included in the experiment primarily as a control so that we could evaluate pest populations with no vegetation between the tree rows. Although the residual herbicide treatment may be easier to manage and require less costly and lighter equipment, winter annual cover seems more desirable for other management reasons, particularly because of reduced water use.

The level of ant activity in orchard A in 1987 warranted treatment with an insecticide in the clover, bromegrass, and resident covers. Ant control added $24 per acre to the management costs of these vegetative covers.

It should be pointed out again that the relative costs of each management regime depend strongly on the price of water and the price of herbicides used for chemical mowing. Any major changes would change the results of the cost estimates and the relative cost efficiencies.

TABLE 1. Costs to establish planted cover crops

Item	Salina strawberry clover	Blando bromegrass
	$/acre	*$/acre*
Springtooth cultivation	5	5
Planter rental	4	4
Seed	34	54
Fertilizer	16 *	11 ◊
TOTAL COST	59	74

* Applied first year only.
◊ Applied every year.

TABLE 2. Annual costs per acre of alternative orchard floor management practices

Item	Mow clover	Mow brome	Mow weeds	Chem. mow	Mow & cultivate	Cultivate	Residual herbicide
	$						
Weed control, tree row	29	29	29	29	29	29	29
Weed control, middles:							
Herbicide	—	—	—	39	—	—	50
Mow middles	31	31	35	—	18	—	—
Disk, springtooth, roll	—	—	—	—	20	32	—
Pre-harvest herbicide	—	—	—	—	10	10	10
Establish cover crop*	5	7	—	—	—	—	—
Fertilize cover crop	—	11	—	—	—	—	—
Subtotal	36	49	35	39	48	42	60
Irrigation	112	92	113	94	113	94	94
TOTAL COSTS	177	170	177	162	190	165	183

* Establishment costs from table 1 amortized over 15 years.

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